APPLYING DEMATEL-ANP FOR ASSESSING ORGANIZATIONAL INFORMATION SYSTEM DEVELOPMENT DECISIONS

Kuang-Husn Shih
Toko University, Taiwan
shihsteve33@gmail.com

Wan-Rung Lin
Chinese Culture University, Taiwan
linyumiko@gmail.com

Yi-Hsien Wang
Chinese Culture University, Taiwan
holland@mail2000.com.tw

Tzu-En Hung
Chinese Culture University, Taiwan
moneybaby88@gmail.com

Abstract:
More and more enterprises expect to improve operating efficiency and managerial decision making effectiveness by introducing information systems into the operational procedures. For enterprises, implementing resource management systems can enhance the administrative efficiency of resource management, and create competitive advantages for businesses. This study used DEMATEL (Decision Making Trial and Evaluation Laboratory) and ANP (Analytic Network Process) to solve the complex relations between criteria dimensions, in order to further select the ideal system implementation model. The results showed that, companies with limited resources prefer to choose an out-sourcing implementation model in order to save labor, cost, and time, while ensuring the stability of the system after implementation. Consequently, the competitive advantages of sustainable operation can be enhanced.

Keywords: Technology industry, Information system, DEMATEL-ANP, Out-sourcing, Co-sourcing

1 INTRODUCTION

In a global era of continuously improved information technology, enterprises face fierce competitions from international markets. In response, they strive to meet the ever-changing demands of competitive business environments and enhance managerial efficiency in order to realize business goals. Moreover, they aggressively enter international markets to increase corporate value. Therefore, establishing a comprehensive information system that can meet business needs, while strengthening corporate governance, is imperative. In particular, enterprises in technology-intensive industries face intense market competitions, high risk factors, and shorter product life cycles. These enterprises should introduce a real-time and efficient information management system that is able to integrate the internal resources of the organization into a corporate strategy for scientific and technological improvement. Hence, how to select an information system that is appropriate for technology-intensive and high value-added technological industries with limited resources is an important issue.

Due to rapid changes in the structures of technological industries, an issue of concern is how to effectively implement an information system (Burn and Ash, 2005; Daghfous and Al-Nahas, 2006; Plant et al., 2003). The commonly implemented information systems include ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management), KM (Knowledge Management), etc. Overall, a good information system can maximize the amount of data handled, minimize response time between enterprises and customers, and provide real-time information for users to lower costs and enhance operational performance. BSC (Balanced Scorecard) is a comprehensive framework that combines company vision, strategy, and performance evaluation, and can measure the financial and operational perspectives of enterprises, in order to achieve a balanced state for corporate performance evaluations. The four major dimensions of BSC (Dias-Sardinha and Reijnders, 2005; Figge et al, 2002) are FI (Financial perspective), CS (Customer/Stakeholder), IBP (Internal Business Process), and LG (Learning and Growth).

FI emphasizes how to manage and efficiently allocate resources with the ultimate goal of maximizing profits/shareholders' value. For enterprises, in both financial and non-financial dimensions, all implementation results will ultimately become financial figures. When a company has a comprehensive information system, all employees and executives can obtain the latest information in real time. Hence, FI can reflect the overall performance of an organization. CS focuses on whether the services provided by an enterprise can satisfy customer needs; thus, it is regarded as the lead indicator for the measurement of organizational performance. Enterprises manage customers by satisfying their demands, thus avoiding the risks of customer loss and declining business performance, in order to achieve financial goals. IBP emphasizes whether the operating performance of an organization satisfies the expectations of shareholders and customers. To attract more customers and enhance corporate value, organizations must continuously improve internal processes and maintain a high service level. LG stresses that employees should continue to learn and grow, which accumulates labor capital to strengthen the organizational structure, and enhance its capacity for sustainable development.

In general, there are three methods of introducing an information system into an enterprise, namely, in-sourcing, out-sourcing, and co-sourcing. In-sourcing refers to a company gathering the technology required for a self-developed information system, thus, lowering the cost of system implementation. Out-sourcing is to hire external suppliers to implement an information system with the professional technology and know-how of the system provider. Co-sourcing refers to an enterprise and system supplier jointly implementing the information system, with the enterprise providing the personnel required by the supplier to pass along the professional knowledge. Different implementation mechanisms can promote the success rate of introducing an information system, and selecting an appropriate system has greater results and benefits for the enterprise.

Based on the above, this study employs the four BSC dimensions: FI, CS, IBP, and LG, to evaluate information system implementation decision making. Section 2 discusses literature on information systems and system implementation decision making; Section 3 establishes the information system implementation model; Section 4 presents the empirical analysis on information system implementation of technology industries; Section 5 offers the conclusions and suggestions of this study.

2 INFORMATION SYSTEM IMPLEMENTATION DECISION MAKING

Traditional information systems often focus on enterprise goals, while neglecting the overall operating environment and the importance of real-time information. With rapid Internet and information technology developments, modern enterprises face intense competitions, and the international operations of the enterprises make the business management even more difficult and complex (Poter and Stern, 2001). Therefore, with sufficient budget, enterprises should implement information systems that can meet the market trends and corporate needs in order to establish a new business model in response to changing business environments. The evaluation criteria used in this study are common information systems used by enterprises, including FAS (Tsamenyi et al., 2006; Weisenberger and Angelkort, 2011), MAS (Bouwens and Abernethy, 2000; Gerdin, 2005; Gul and Chia, 1994; Mia and Clarke, 1999); APS (Chen and Ji, 2007; Gould, 1998; Lee et al., 2002), SCM (Akkermans et al., 2003; Bayraktar et al., 2009; Humphreys et al., 2001; Williamson et al., 2004); CRM (Davids, 1999; Du Plessis and Boon, 2004; Pai and Tu, 2011), KM (Du Plessis and Boon, 2004; Prusak, 1997; Probst et al., 1999), executive information system (Elam and Leidner, 1995; Koh and Watson, 1998; Rainer and Watson, 1995; Walstrom and Wilson, 1997), and DSS (Anderson et al., 2008; Blanning, 1993; Haynes and Wilczynski, 2010; Hogue and Watson, 1983; Ma, 1997; Shim et al, 2002; Todd and Benbasat, 1992).

2.1 Types of Information System

FAS (Financial Accounting System) - Financial accounting is usually referred to as external accounting, where the information is the company's overall message. The financial information provided by FAS is mainly for external users (e.g., tax authorities, shareholders of the listed companies, banks, security regulators, etc.) as a reference. Meanwhile, enterprises engage in business activities according to the standards provided by the government and customary practices (e.g., enterprise accounting system, accounting standards, corporate accounting system, etc.), and provide financial statements in specified formats. Tsamenyi et al. (2006) argued that organizations that apply FAS to business activities can bring about positive results for the enterprise. Weisenberger and Angelkort (2011) suggested that the integration of FAS and MAS can enhance the performance of enterprises. The most important feature of FAS is that it can provide accurate, international, and real-time financial information of an enterprise, and when coupled with external and internal accounts receivables and payables, can shorten the cash turnover period. In particular, it can facilitate the long-term planning of overseas investment to enhance business operating efficiency. Hence, these financial statements are often used in investment decision making, evaluations of overall operating conditions, and as a method to monitor an enterprise for violations of regulations and laws.

MAS (Management Accounting System) - Management accounting is often referred to as internal accounting. There is no consistent scholastic definition of MAS. Some scholars argue that MAS is an information system controlled by the organization to provide information to managers (Bouwens and Abernethy, 2000; Gul and Chia, 1994). MAS is the official information system used by organizations to affect the behaviors of management in order to achieve the organizational goals (Gerdin, 2005). MAS provides internal enterprise users, such as the management, the production department, and the R&D department, with the financial information of the enterprise. Such financial data facilitate the implementation of decisions regarding internal production in-sourcing, out-sourcing, etc.

Chenhall and Morris (1986) suggested that MAS has the following features: 1) wide range; 2) timeliness; 3) summation; and 4) integration. Wide range refers to non-financial information related to the external environment of the enterprise. Timeliness provides managers with the latest information in the shortest time. Summation refers to data, which are summed through the analysis model, calculated by time or functional regions. Integration includes specific goals that explain the interactive effects among the departments; it is the information regarding the impact of the decisions of a certain department on the operations of other departments. Tsui (2001) indicated that information with a wide range and timeliness can help managers to settle on more informed decisions, which affect organizational performance. Mia and Clarke (1999) suggested that the use of MAS information by managers is positively correlated to organizational performance. Management accounting information is the most needed information for the internal management of an enterprise, as well as the most important part of DSS of the enterprise. MAS can provide detailed and accurate cost information, including the basic information for a variety of managerial activities, such as product pricing, product

cost control, out-sourcing decision making, and departmental performance evaluations. Hence, as an information system that provides accurate cost information will deliver more commercial interest to an enterprise, it is a necessary investment.

APS (Advanced Planning and Scheduling) **-** From the perspective of planning content, APS solutions include material planning, production planning, capacity planning, finite capacity planning, etc. In cases of a company with multiple production factories, the headquarters must clearly know each factory's production information, as company internal processes and efficiency affect the smooth implementation of overall planning (Kerschbamer and Tournas, 2003). APS can simulate and calculate expected delivery times and quantity of orders in order to immediately respond to customer demands, thus achieving timely deliveries and improved productivity.

Flesischmann et al.(2000) proposed that APS has features of synchronized concurrent planning, optimization planning, real-time planning, and decision support capability. Since APS can simulate the planning of raw materials and capacity resource limits, it can help decision makers to carry out synchronized concurrent planning of raw materials and production capacity, and quickly generate an optimized production schedule. In sum, APS can help decision makers with limited resources in the timely determination of optimal plans and corresponding decisions. Moreover, APS has received considerable attention in the information systems of the enterprises (Chen and Ji, 2007; Gould, 1998; Lee et al., 2002).

SCM (Supply Chain Management) - SCM can increase the flexibility of production processes, transport speeds, available information, and manage complexity in production. In recent years, many scholars have explored topics regarding SCM capabilities and performance (Closs and Mollenkopf, 2004; Davids, 1999; Du Plessis and Boon, 2004; Pai and Tu, 2011; Park et al., 2007). The major focus of SCM is the application of the information system for the integration of purchases, operations, and logistics, from raw materials to finished products that meet customer demands (Kovacs and Paganelli, 2003). Closs and Mollenkopf (2004) argued that all activities relating to delivering a product to market are a part of a supply chain.

Park et al. (2007) suggested that SCM is an important part of an enterprise, and used the four dimensions of the BSC model as the evaluation factors to measure SCM performance. Closs and Mollenkopf (2004) pointed out that SCM capabilities include customer integration, integration of raw materials, service supply, integration of technology and planning, and integration of measurements and relations, which integrate the major internal and external SCM activities, and enhance its performance. Hence, SCM has become an important resource for enterprises to improve organizational productivity and strategies that enhance operating efficiency.

CRM (Customer Relationship Management) **-** With ever-increasing consumer demands, enterprises can query and access complete customer data by the CRM system. Through a complete collection of the basic data and shopping preferences of customers, enterprises can develop optimal selling plans and strategies for different types of customers, thus fully utilizing the resources. CRM is the management system for the overall strategy of an enterprise, which integrates business functions, including selling, customer service, marketing, and quick responses. By CRM, enterprises can predict customer needs to enhance organizational effectiveness and efficiency (Du Plessis, and Boon, 2004). CRM uses highly efficient information technology to rapidly collect and analyze customer information, and implement efficient customer interactive services that enhance customer satisfaction and loyalty (Davids, 1999).

Using CRM, enterprises can increase market opportunities, improve organizational competitiveness, and create high customer value. However, when implementing the CRM system, enterprises should integrate information technology, information resources, and organizational resources in order to obtain optimal efficiency and effectiveness (Pushkala, et al., 2006). Hence, to develop products and services that meet customer needs, enhance customer loyalty, and generate higher profits, enterprises should establish a complete customer information system to manage relations between enterprises and customers.

KM (Knowledge Management) **-** In the 21st century, knowledge has taken the leading place over

capital and labor. The success or failure of a knowledge-based economy is determined by globalized competition, product marketing time, and organizational response capabilities. When introducing KM, management personnel should actively participate in the process to fit the KM into the company's strategy, rather than regard it as the best strategy. Nonaka (1994) divided knowledge into tacit knowledge and explicit knowledge. Tacit knowledge refers to the knowledge of individual subjectivity, which is deeply rooted in the intellectual model of personal experience, judgment, association, and sub-consciousness. Explicit knowledge refers to knowledge that can be represented by figures or numbers, namely, data that can be defined and acquired. Alavi and Leidner (2001) divided knowledge into declarative, procedural, causal, contextual, and relational knowledge, according to the dimensions of understanding phenomena.

From an organization's point of view, a KM system includes personnel, technology, and data or information; these elements interact for various purposes, such as a product distribution system. Gallupe (2001) indicated that a KM system is an information tool and technology of the organization, which is in place to support KM practices. Davenport et al. (1998) suggested that KM systems can provide decision makers or users with the necessary knowledge for decision making and implementation of working systems. In academia, topics regarding the correlation between KM and KM systems (Bock et al., 2005; Kankanhalli et al., 2005) have attracted increasingly attention. KM performance and business performance are mutually influential (Lin and Tseng, 2005; Liu, 2011). Hence, a KM system is a considerably important tool to enhance corporate performance.

EIS (Executive Information System) **-** When executives are conducting decision making management activities, they must learn the information of other organizations and acquire external information, thus, management information systems are often used to obtain the required information (Volonino et al., 1995). However, one important concern of implementing an executive information system is that lacking the support from senior executives or without an appropriate system interface, the implementation of the executive information system may likely to fail. Watson et al. (1995) suggested that, the key factor of implementing an executive information system is to provide executives with more convenient, real-time access to data and information, and secondly, to enhance the executive's job performance.

Watson et al. (1991) found that the pressure on executives comes from both inside and outside the enterprises. The external pressure is the intense competitive pressure arising from rapid market changes; the internal pressure is from executives' expectation to obtain real-time information and improve internal communications, when facing tremendous competitive pressure. As the executives tend to use computer systems to make decisions, they have greater demands on information and the speed of the information system (Hung, 2003). In other words, the quality of the executive information system remains an issue of concern to enterprises (Xu et al., 2003). Hence, by implementing an executive information system, enterprises can reduce the workload of report printing, while the middle level and senior executives can use information technology to gain competitive advantages.

DSS (Decision Support System) **-** DSS is a computer-based information system that provides information through conversation and fast operation to assist decision makers to solve unstructured problems (Anderson et al., 2008; Haynes and Wilczynski, 2010; Shim et al, 2002). DSS can enable decision makers to use the data of other information systems of the enterprise to analyze and integrate relevant data, in order to generate information that can help improve decision making performance. Hence, this system can allow decision makers to set standards, problems, and analysis fields, as well as define new rules with new attributes to integrate them with the working environment. In sum, DSS stresses the enhancement of individual and organizational performances, rather than the enhancement of data processing efficiency.

Company managers and decision makers use DSS to improve the efficiency of decision making processes (Blanning, 1993; Ma, 1997), and DSS provides support, rather than replacement, on the decision making (Shim et al, 2002). The increased decision making efficiency indicates the improved effectiveness of the DSS (Todd and Benbasat, 1992). The reason to adopt DSS is that enterprises require accurate and real-time information to reduce costs and meet managerial needs. Therefore, DSS is regarded as an important information system to organizations (Hogue and Watson, 1983).

2.2 System Implementation Decision Making

Enterprises may in-source the task of system implementation to their employees, or out-source it to consulting firms or system suppliers. However, co-sourcing, which is an approach that integrates in-sourcing and out-sourcing, brings the advantages of both methods for business management. The characteristics of the three methods of decision making are explained, as follows.

In-sourcing **-** The in-sourcing model is a type of contingency measurement to ensure output value, as it takes the tasks of other departments and improves the operations within a certain field. It can store technology, develop assets, and reduce the unit costs of the in-sourcing business. In-sourcing decision making is to control major production process resources in order to protect the confidential data or technology of the company. Moreover, it is mainly applied to tasks of added-value, and it aims to achieve the ideal operating efficiency and optimal use of resources (Venkatesan, 1992).

In-sourcing means an inflow of resources, namely, the internal production processes of an enterprise are assigned to an internal professional team. In other words, an enterprise should retain its key services or core values, and requires the information department to provide important strategies regarding task implementation and activities, in order to achieve the overall goals of the enterprises. Hence, when an enterprise assigns a production activity or project service through in-sourcing, the service provider can provide management and service for the internal information system, and meet the requirements for sustainable business. In-sourcing includes the development of new systems, management information requirements, etc. Since the system is self-developed within the company, it is often characterized by a high degree of complexity; however, the development process requires high costs, labor, and time. Even after introducing such a system, it may be unstable due to immature introduction technology. In other cases, the system may be highly complex due to excessive focus on detailed functions, and thus, the extensibility of the system is limited. Hence, the introduction of in-sourcing information system often encounters problems of excessively high costs and time, inability to modify the system by maintenance staffs, and even terminating the use of the entire system.

Out-sourcing **-** In recent years, out-sourcing decision making has been widely applied in various industries, including management services, human resources, telecommunications, food and beverages, and information system (Jharkharia and Shankar, 2007). Out-sourcing decision making aims to appropriately allocate the technology and resources of the enterprise through a contract that generates maximum benefits (Lacity and Hirschheim, 1993). An enterprise assigns some tasks to outsourcers in order to utilize the professional capabilities of the outsourcers to meet operational requirements (Quinn and Hilmer, 1994). Outsourcers can obtain important resources from external environments to strengthen the operational efficiency of the enterprises (Gupta and Zhender, 1994; Han, et al., 2008; Jennigs, 1997; Yang and Huang, 2000). In terms of business interests, the out-sourcing model can concentrate the resources of the enterprise for strategic use. Regarding inexperienced or small tasks, an enterprise can obtain external resources through the out-sourcing model. In addition to satisfying the needs of the enterprise, this model can save time, labor, and costs to maintain competitiveness.

If outsourcers can complete the tasks more efficiently and at a lower cost, then it is more appropriate for the enterprise to outsource the tasks (Minoli, 1995). The advantage of out-sourcing is to enable the enterprise focusing on core businesses that can improve service value and reduce the operating costs of the enterprise; hence, many enterprises contract outsourcers for system implementations. The main reasons for choosing the out-sourcing model when implementing an information system are to reduce operating costs, concentrate resources, and strengthen the information capability of the enterprise. In addition, with rich experience in system implementation, consulting firms can provide optimized practices. As outsourcers can provide different parameter settings and plug-in programs according o the enterprise characteristics, more and more enterprises have purchased customized information systems.

The time required for system implementation will be shorter if done by professional consultants or system suppliers, while the labor input of the enterprise is also lessened. Consultants and system suppliers can also provide the best practices for reference to help correct the process restructuring, thus reducing the risks and losses of system implementation, and increasing data accuracy and system stability. Out-sourcing is a long-term cooperative relationship between the enterprise and the

supplier. The two parties need to invest in the cooperative relationship before sharing the benefits as termed in the contract. As both parties need to share the risks, if the benefits cannot be realized, the suppliers may not have any returns, despite their input and efforts.

Co-sourcing **-** The co-sourcing model is a partnership between an enterprise and a supplier. It means a long-term cooperation relationship that shares the risks and benefits to realize a common goal, and is based on mutual trust. The cooperative relationship of co-sourcing is closer than that of the out-sourcing model; specifically, it is a mutually recognized and cooperative relationship of long-term development and trust at all levels. Both parties should implement the plan according to strict rules and trust each other. In the co-sourcing model, the outsourcer passes the professional skills or technologies to the personnel or managers assigned by the enterprise, who will share the knowledge and skills to other members of the enterprise. In the past, executives tended to reject the out-sourcing model to retain the personnel, however, the co-sourcing model makes both parties responsible for the provision of required resources to achieve the common goals (Borman, 2006).

When the enterprise and the supplier implement an information system through cooperation, both parties are obligated to fulfill the signed contract. During the system implementation process, the outsourcer is responsible for some tasks, while the information project team members take charge of other tasks. The co-sourcing model is the most effective resource sharing method, as it can assist an enterprise to complete the information system implementation by utilizing the personnel from both parties. Moreover, the level of control over the entire project is relatively higher for the enterprise (Kishore et al., 2004). Establishing a long-term partnership between an enterprise and a supplier can strengthen the communication capabilities between them, improve order processing processes, and accurately use the supplier's technology to improve product development, thus enhancing the overall operational management of the enterprise.

The difference between co-sourcing decision making and in-sourcing decision making is that co-sourcing decision making allows out-sourcing some of the company activities to the supplier, and encourages both parties to maintain medium and long-term cooperative relations (Jennigs, 1997). Hence, the enterprise maintains strategy determination rights, including technological innovations, redefinition of policies, information decision making, etc., while the supplier regularly implements relevant operations to provide the latest information and suggestions. A common problem of cooperation between an enterprise and a supplier is changes in personnel. When the original members leave or assigned elsewhere, the enterprise may not be able to maintain continuity with the supplier, resulting in reduced cooperation satisfaction, and even disbanding of the partnership. Hence, the enterprise and the supplier should maintain a high degree of satisfaction and trust, and continuously improve the partnership.

3 EVALUATION MODEL

DEMATEL (Decision Making Trial and Evaluation Laboratory) can effectively solve issues of complexity and dependency among the criteria, and has been widely applied in market strategies, R&D projects, e-learning evaluations, management systems, control systems, and flight safety (Chiu et al., 2006; Lin and Wu, 2008; Liou et al., 2007; Tsai and Chou, 2009; Tzeng et al., 2007; Wu and Lee, 2007b). ANP (Analytic Network Process) can determine the weights of various criteria, and evaluate feasible alternative plans according to these weights. ANP has been applied in project evaluation (Lee and Kim, 2000; Meade and Presly; 2002), production scheduling (Karsak et al., 2002; Lin et al., 2008), and KM strategy evaluations (Leung et al., 2006; Ravi et al., 2005; Wu and Lee, 2007b). Thus, this study applies the DEMATEL to establish the correlation between the mutual effects of the organizational perspectives, and uses ANP to determine the weights of the information system and system implementation decision making (Huang et al., 2005). Finally, this study determines the ideal system implementation decision making. The research processes and architecture are as shown in Figure 1.

3.1 DEMATEL (Decision making trial and evaluation laboratory)

This study used the DEMATEL method to establish the network relationship among organizational dimensions. When an enterprise is evaluating information system implementation decision making, many criteria must be considered. The most common problem is the mutual effects of criteria. Hence,

it is necessary to identify the criterion that has the greatest impact on other criteria prior to the evaluation, in order to improve the overall performance, as well as the quality and efficiency of the organizational information system. The DEMATEL method was developed between 1972~1976 by the Battelle Memorial Institute for the Science and Human Affairs Program. Since the DEMATEL method can solve issues of complex dependency and provide feasible plans through its hierarchical structure (Tzeng et al., 2007), applications of the methods are extensive, ranging from industrial planning, decision making in production planning, design, and regional environmental evaluation (Huang et al., 2007). The DEMATEL method is applied to solve the complex dependency issues among criteria. The four steps of method calculation are described as follows:

Step 1: Generate an original impact matrix (***A***)
The calculations of the original mean matrix are conducted by pairwise comparisons of dimensions (criteria) to evaluate the perceived level of impact of each respondent regarding the dimensions (criteria). The evaluation scale ranges from 0 to 4, where 0 represents no impact among the dimensions (criteria); 1 represents a low level of impact; 2 represents a medium level of impact; 3 represents a high level of impact; and 4 represents an extremely high level of impact (Chiu et al., 2006). The original mean impact matrix (**A**) can be obtained by the average of the summation of the expert answer matrices.

Step 2: Calculate the direct impact matrix (***M***)
First, obtain the maximum values of all rows or columns of the original mean matrix (***A***), then apply Eqs. (1) and (2) to normalize the processes to obtain the direct impact matrix (***M***); next, conduct priority ranking of the direct impact matrix among dimensions (criteria) by using the summations of the rows and columns of the direct impact matrix (***M***), where, *i* and *j* denote the dimensions (criteria).

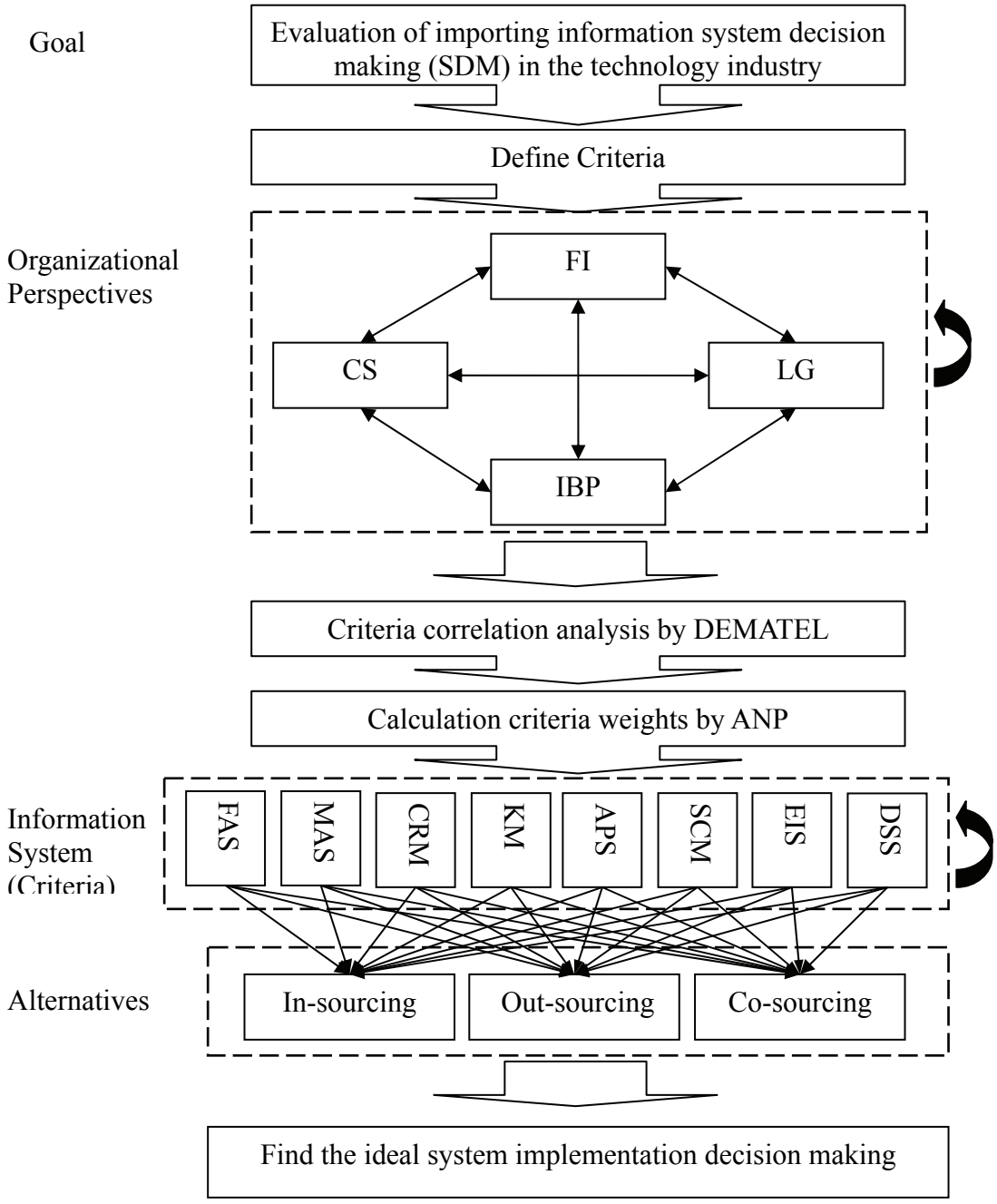
$$\boldsymbol{M} = k \cdot \boldsymbol{A} \tag{1}$$

$$k = Min\left(\frac{1}{\max\limits_{1 \le i \le n} \sum\limits_{j=1}^{n} \left| a_{ij} \right|}, \frac{1}{\max\limits_{1 \le j \le n} \sum\limits_{i=1}^{n} \left| a_{ij} \right|} \right), \quad i, j = 1,2,3,...,n \tag{2}$$

Step 3: Calculate the total impact matrix (***T***)
By Eq. (3), the total impact matrix (***T***) can be obtained.

$$\boldsymbol{T} = \boldsymbol{M}\,(\,\boldsymbol{I} - \boldsymbol{M}\,)^{-1} \tag{3}$$

Figure 1: Research process and architecture



Next, through Eqs.(4)~(6), obtain the column (element) sum vector (***D***), and the reverse of the row summation vector (***R***); then, add up the column sum vectors (***D***) and the reverse of the row sum vector (***R***) to obtain the row and column sum vector (***D + R***); subtract the column vector (***D***) and the reverse of the row vector (***R***) to obtain the row and column difference vector (***D - R***) (Wu and Lee, 2007a). When the value of (***D + R***) is higher, it means that the mutual effects of the dimensions (criteria) are greater (Seyed-Hosseini *et al*., 2005). The difference vector (***D - R***) represents the net impact of the total impact matrix. If (***D - R***>0), it means that the dimension (criterion) has greater impact on other dimensions (criteria) than the impact of other dimensions (criteria) on it, hence, it is referred to as the dispatcher. On the contrary, if (***D - R***<0), the dimension (criterion) has a smaller impact on other dimensions (criteria) than the impact of other dimensions (criteria) on it, and hence, it is referred to as

the receiver.

$$\boldsymbol{T} = [t_{i,j}]_{n\times n} \qquad i,j = 1,2,3,...,n \tag{4}$$

$$\boldsymbol{D} = \sum_{j=1}^{n} t_{i,j} \tag{5}$$

$$\boldsymbol{R} = \sum_{i=1}^{n} t_{i,j} \tag{6}$$

Step 4: Structural correlation analysis

After obtaining the total impact matrix, analyze the impact relations of the value of (***D* - *R***) and the value (D ***+ R***) by diagram to obtain the structural correlation impact figure.

3.2 ANP (Analytic Network Process)

Proposed by Saaty in 1996, ANP can solve dependency issues and feedback relations among multiple criteria. The ANP method uses Super Decision software to calculate the weighted supermatrix. First, experts conduct pair-wise comparisons of the importance of the criteria, according to a scale of 1~9 (Saaty, 1996), then the system determines the relative weights (such as Eq. (7)). Using the ANP method to evaluate decision making problems mainly includes three steps (Saaty, 2006): 1) establish the evaluation network hierarchical structure; 2) calculate the weights of the elements at all levels; and 3) calculate the weight of the overall hierarchy.

$$W_i = \frac{\sum_{j=1}^{n}\left(a_{ij} / \sum_{i=1}^{n} a_{ij}\right)}{n}, \qquad i,j = 1,2,3,...,n \tag{7}$$

4 EMPIRICAL ANALYSIS

In order to clearly understand the different views of experts and scholars regarding the decision making of implementing information systems in technological industries, this study invited three academic experts, five information system consultants, and seven industrial experts for criteria pairwise comparisons and importance weight analysis. The empirical results included two parts: the first part is the relations of the impacts among the four organizational dimensions of the technology industry; while the second part is the selection of information system implementation decision making through ANP.

4.1 Establish the correlation structure diagram for evaluation dimensions

This study used the DEMATEL method to construct a structural correlation diagram of the organizational dimensions of the technology industry as a reference basis for information system implementation. As shown in Table 1, CS has a high degree of impact on FI (3.733), and LG has a low degree of impact on FI (1.867).

Table 1: Original impact matrix

Dimension	FI	CS	IBP	LG
FI	0.000	2.600	2.600	1.933
CS	3.733	0.000	3.333	2.200
IBP	2.667	2.400	0.000	2.467
LG	1.867	2.000	2.067	0.000

According to the normalization process of Eqs.(1) and (2), the maximum value of the sum of all rows and columns of the original impact matrix (***A***), namely, the sum of the rows of CS (9.267), is obtained. The direct impact matrix (***M***) is also obtained (Table 2). The sum of rows and columns are then added to rank the impacts by priority (Table 3). As seen in Table 3, CS is the dimension of the highest priority in the direct impact matrix, and LG is the dimension of the lowest priority in the matrix.

Table 2: Direct impact matrix

Dimensions	FI	CS	IBP	LG
FI	0.000	0.281	0.281	0.209
CS	0.403	0.000	0.360	0.237
IBP	0.288	0.259	0.000	0.266
LG	0.201	0.216	0.223	0.000

Table 3: Comparison of direct impact matrix

Dimension	Column Sum	Row Sum	Addition of Columns and Rows	Priority Ranking
FI	0.771	0.892	1.663	3
CS	1.000	0.756	1.756	1
IBP	0.813	0.864	1.677	2
LG	0.640	0.712	1.352	4

Eq. (4) is used to obtain the Total Impact Matrix(***T***)(Table 4), and Eqs. (4)~(6) are used to obtain the column addition vector of the Total Impact Matrix (***D***), the reverse of the row addition vector (***R***), the addition of the row and column (***D + R***), and the difference of row and column (***D - R***), are as shown in Table 5. As seen, the addition of the row and column vector of CS (***D + R* = 9.432**) is the highest, indicating that the mutual effects of CS and other dimensions are the greatest. The row and column difference vector (***D - R***) represents the net impact relationship of the Total Impact Matrix. The row and column difference vector of CS (0.968) is greater than zero, suggesting that the impact of CS on other dimensions is greater than the impact of other dimensions on CS. Hence, CS is the dispatcher. On the contrary, the row and column difference vectors of FI (-0.462), IBP (-0.216), and LG (-0.309) are below zero, suggesting the impact of these three dimensions on CS is lower than the impact of CS on the three dimensions, thus, the three dimensions are the receivers.

Table 4: Total impact matrix

Dimension	FI	CS	IBP	LG
FI	0.937	1.042	1.131	0.952
CS	1.436	1.007	1.380	1.143
IBP	1.186	1.053	0.938	1.013
LG	0.965	0.878	0.958	0.665

Table 5: Total impact matrix comparison

Dimension	Column Sum (***D***)	Row Sum (***R***)	Addition of Column and Row (***D + R***)	Difference of Column and Row (***D--R***)
FI	4.062	4.524	8.586	-0.462
CS	4.966	3.980	8.947	0.986
IBP	4.190	4.406	8.171	-0.216
LG	3.465	3.774	7.239	-0.309

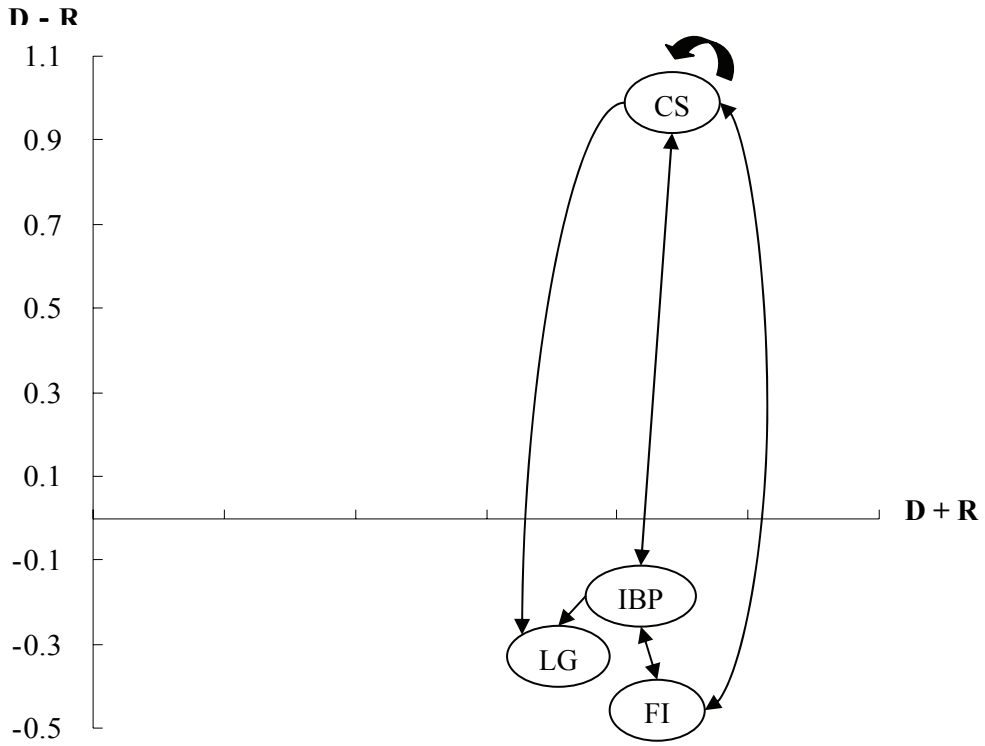
In this study, the threshold value for the judgment of dimension correlation is set at 1.0, which is the average value (1.043) of the total Impact Matrix (Table 4), after rounding off. The threshold value of 1.0 can be used to judge the correlation among dimensions. The structural correlation impact diagram can be determined using the (***D - R***) and (***D + R***) values of the Total Impact Matrix (Figure 2).

4.2 Network Hierarchical Analysis

Based on the analytic hierarchical programming method, ANP can be divided into four stages, which are establishing architecture and problems, pair-wise comparison among groups, formation of the supermatrix, and the selection of optimal options. First, it determines the goals according to the attributes of the problem, and finds the mutual effects of decision making criteria. Then, it uses the

pair-wise comparison matrix to determine the eigenvector as the value of the supermatrix, which illustrates the dependency and relative importance among the groups. The eigenvector obtained by pair-wise calculation is then used as the weight value for the sub-matrix to form the supermatrix. Finally, the multiple operations of the supermatrix result in a fixed convergence of the extreme values (weights), which is the basis for the priority ranking of options for evaluation.

Figure 2: Structural correlations impact diagram



As ANP can handle criteria dependence and feedback relations, it can be applied as a tool to solve practical problems. After confirming the relational structure of the decision making dimensions for information system implementation, this study applied ANP to determine the weight of each criterion. First, experts were invited to measure the importance of the criteria of the 71 items through a pair-wise comparison on a scale of 1~9 (Saaty, 1996). Then, the *Super Decision* system software was used to calculate the relative weights. After the operations of the pair-wise comparison matrix, the C. I. (Consistency Index) was used to judge the consistency of the expert evaluations[1].

As shown in Table 6, the final ANP weights are (In-sourcing = 0.130, Co-sourcing = 0.312, Out-sourcing = 0.558). By these weights, it can be concluded that the out-sourcing model is the best solution, and is the decision of top priority for information system implementation. The co-sourcing model is the second best option, and is the decision of secondary priority. The in-sourcing model is the worst option, and the decision of last consideration.

Table 6: Limit matrix value

		Alternatives		
		In-sourcing	Out-sourcing	Co-sourcing
Goal	SMD	0.130	0.312	0.558*
	FI	0.129	0.299	0.572*
Perspectives	CS	0.132	0.323	0.546*
	IBP	0.129	0.298	0.573*

[1] Staay (1980) suggests, if the C.I. value is below 0.1, it is a reasonable deviation.

	LG	0.132	0.323	0.545*
Information System (Criteria)	FAS	0.128	0.227	0.645*
	MAS	0.125	0.268	0.608*
	CRM	0.129	0.337	0.534*
	KM	0.136	0.277	0.587*
	APS	0.118	0.267	0.615*
	SCM	0.111	0.257	0.631*
	EIS	0.157	0.380	0.463*
	DSS	0.131	0.393	0.476*

* indicates the highest weighted value

5 CONCLUSIONS AND SUGGESTIONS

In the competition of e-business, information system is an important strategy to strengthen the competitive advantages of enterprises, rather than a mere tool (Henderson and Venkatramen, 1993). In response to the market changes, as well as the improvement of competitiveness, enterprises must continuously develop different types of strategies to solve problems. This study integrated the DEMATEL and ANP methods to explore decision making for implementing an information system in the technology industry. Since the evaluation process of decision making should consider the issues of mutual effects among criteria, this study solved the interdependency issue of criteria, and used the ANP method and the results to determine the weights of the final decision making plan, in order to determine the ideal system implementation decision making option.
The research findings suggested that, when implementing different types of information systems, the out-sourcing model is the most preferred option of enterprises, as evidenced by the highest weights. The reason is that consulting firms or suppliers have rich experiences and optimization practices, and the provided system has different parameter settings and plug-in programs to fit the needs of the enterprises. In terms of the entire implementation process, the services provided by consulting firms or suppliers can considerably shorten the overall implementation time, while their professional expertise can effectively enhance system stability. In terms of costs, although the enterprises need to pay a higher cost for purchasing the services and expertise of the consulting firms or suppliers, the effectiveness of the systems is enhanced.

The second best option is the co-sourcing model, as evidenced by weighted values. Although the relationship between enterprises and outsourcers assuming this model is closer than that of the out-sourcing model, and the enterprises have more controls over the system implementation, the responsibilities and risks to be borne by the enterprises are also higher than the out-sourcing model. For enterprises, it is the ideal option to implement an information system with stable quality, the lowest cost, least manpower, and time. Nevertheless, the co-sourcing model is a long-term partnership requiring exchanges between the two parties, which require more cost, labor, or time than the out-sourcing model. Hence, the weight of co-sourcing model is lower than that of out-sourcing model, which is consistent with actual situations.

In-sourcing model is the final option for enterprises, possibly because the development stage requires a great deal of effort in system analysis and programming. During system implementation, enterprises should pay attention to the development schedule to avoid overly long development process, which would increase costs. Moreover, the lack of relevant knowledge and experience of internal employees in system implementation may result in wrong judgments and resource wastes. Hence, when enterprises intend to introduce a system independently, they must carefully evaluate the information system and assign experienced information personnel to help in the development, and thus, bring about the maximum benefits of self-development.

This study combined DEMATEL and ANP to evaluate a feasible information system implementation model. The two methods are widely applied as they can effectively solve the dependency of criteria and provide quantified decision making models to help decision makers in the selection of the ideal plan for maximum effects and effectiveness. When implementing information systems, enterprises are also concerned about investment costs and the quality of services provided by outsourcers. Hence, future studies may focus on the evaluation and selection of the best outsourcer with limited resources.

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